

BLACK FLIES (DIPTERA: SIMULIIDAE) AND A NEW SPECIES OF CADDISFLY (TRICHOPTERA: HYDROPSYCHIDAE) IN A NORTHWESTERN GEORGIA CAVE STREAM¹

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ABSTRACT: Larvae of *Prosimulium saltus*, *Simulium parnassum* (Diptera: Simuliidae) and a new species of *Diplectrona* (Trichoptera: Hydropsychidae), were collected in 1998 from a cave stream in northwestern Georgia, USA. Simuliidae have not previously been reported from Nearctic cave streams. The cavernicolous simuliids were morphologically similar to those collected on the surface but with less pigmentation. The collection of *P. saltus* is a state record and marks the known southern extent of the species. The adult male, larva, and pupa of the new *Diplectrona* are described and compared with other known *Diplectrona* species.

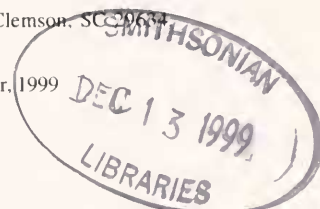
Cavernicolous invertebrates can be separated into three classes. Troglonites are obligate cave dwellers, with specific adaptations for a cave or cave system (Gertsch 1979). Trogloniles are facultative cave dwellers. Troglonenes are cave dwellers that must return to the surface to fulfill part of their life cycle (Barr and Holsinger 1985).

Troglonilic aquatic Diptera in the families Chironomidae, Dixidae, and Psychodidae have been reported in southeastern caves (Holsinger and Peck 1971, McDaniel and Smith 1976, Peck and Lewis 1978, Peck 1995, Peck 1998). The known Nearctic simuliid larvae with cavernicolous modifications are *Parasimulium crosskeyi* Peterson and *Pa. stonei* Peterson, which are found in the hyporheic zone (Courtney 1986). Larvae of these species have many similarities with troglonitic organisms including apparent blindness and lack of pigmentation (Courtney 1993). The adults are not cavernicolous and are found on trees near seepages (Wood and Borkent 1982). Both species could be categorized as troglonenes, because they must fulfill part of their life cycle outside the cave environment.

Peck (1995) suggested the possibility of cavernicolous Trichoptera in the southeastern U.S., but no further study has ensued. Records exist for Trichoptera in Texas caves, but the specimens were identified only to the ordinal level (Reddell 1966). Outside the Nearctic region, Polycentropodidae have been collected from a cave in Japan (Sato 1964). Species of Limnephilidae are found in the caves of Turkey, France, Italy, Germany, and Romania (Nimmo 1996). One of these cavernicolous Trichoptera, *Micropterna testacea* Gmel, has been collected 300 meters into a cave (Bitsch and Frochot 1962). In French caves, *M. testacea* is a troglonene with cave-dwelling larvae and adults that emerge and disperse (Bournaud and Gautheron-Duranthon 1969).

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MATERIALS AND METHODS

Collections were made at two sites on an unnamed subterranean stream in Newsome Gap Cave, Dade County, Georgia (34° 47' N, 85° 28' W, 430-m above mean sea level). One site was in total darkness 14-m from the main entrance of the cave. The second site, located 1-m upstream of the main entrance and 3-m from a small side entrance was partially lit. Collections began on 13 March and continued through 22 May 1998.

Specimens were preserved in Carnoy's fixative (1 part glacial acetic acid: 3 parts 95% ethanol), and voucher specimens were deposited in the Clemson University Arthropod Museum and the U.S. National Museum, Washington, D.C.

The cave stream was physically characterized at the mouth by measuring pH, conductivity, temperature, discharge, depth, width, surface velocity, and substrate composition. Depth was averaged from three evenly spaced measurements across the stream. Conductivity was measured with a conductivity meter (model 19820-00, Cole-Parmer), and pH was measured with a pH/mV/ORP meter (model 5938-00, Digi-Sense).

The subterranean streambed had a nearly uniform width of 1-m. The substrate was sandstone-limestone bedrock with coarse sand to boulder overlay. Temperature varied between 12° and 15°C, pH from 8.3 to 7.8, and conductivity from 110.7 to 121.0 micro-siemens. The spring discharged 0.026 m³/sec at the cave mouth on 13 March.

The stream flows year-round through the subterranean passages, but becomes intermittent after leaving the cave. No leaves or other indications of surface intrusions were found inside the cave. At least one subterranean tributary joins the main stream before the cavern becomes inaccessible to humans. On 27 March, the surface stream gradually sank into the substrate approximately 40-m beyond the mouth of the cave.

Caddisfly larvae collected in the cave stream were observed in the laboratory in 1.5-m long by 15-cm wide artificial laboratory streams. The streams remained at 19-21°C in complete darkness. Larvae were fed every three days. Food consisted of larval Simuliidae, dead phorids (*Megaselia cavernicola* Brues), wax moths, and TetraMin® fish food flakes. Food was removed after 24 hours if not consumed.

Diplectrona marianae Reeves, NEW SPECIES

Figs. 1, 2, 3

HOLOTYPE MALE: Length of male from front of head to tips of folded wings: 10.13-mm; Length of antenna 7.6-mm. Warts and other structures on dorsum of head (Fig. 3.) similar to those of *D. rossi* (Fig. 4).

Male genitalia: Inferior appendages each 1.14-mm in length, slender at base and broadening near the apex, then narrowing again. Inferior appendages lightly sclerotized, setose apically. Phallus simple, blunt, 0.65-mm long.

Larva: Length of mature larva: 12.7-15.9-mm. Head capsule width 1.74-mm. Left mandible (Fig. 1 and 2) 0.82-mm long, 0.57-mm wide at base. Left mandible with prominent ridge process.

Pupa: Length of pupa: 9.1-9.3-mm from head to abdomen; 5 teeth on left mandible, 4 teeth on right mandible.

Holotype: Male, Newsome Gap Spring Cave, Dade County, Georgia, USA, May 22 1998, N 34° 47', W 85° 28', 430-m elevation, collected by Will K. Reeves. Holotype deposited at the U.S. National Museum, Washington, D.C. **Paratypes:** 2 pupae and 4 larvae same data.

Diagnosis: The genitalia of most *Diplectrona* spp., including *D. marianae*, lack dorsal lobes on the tergum, which are present on the tergum of *D. californica* Banks (Morse and Barr 1990). The lack of dorsal lobes on the tergum is diagnostic for separating *D. marianae* from *D. californica*. Because the dorsolateral lobe was not truncate, *D. marianae* can be diagnosed from *D. rossi* Morse and Barr. The genitalia of *D. marianae* were not differentiable from those of *D. modesta* Banks and *D. metaqui* (Ross), which have very similar genitalia. The warts on the head have been used to differentiate species of *Diplectrona* (Morse and Barr 1990). The warts on the head of *D. marianae* resemble those of *D. rossi* (Fig. 4), and differ from those of *D. modesta* (Fig. 5) and other similar species of *Diplectrona*. Larvae are similar to those of *D. metaqui* in general structure. *Diplectrona marianae* is the sister species of *D. metaqui* based on similar larval head-capsule patterns, notched frontoclypeal apotome, and mandibular process. Larvae of both species differ from those of other species of *Diplectrona*, because of the mandibular processes. *Diplectrona marianae* larvae can be differentiated from those of *D. metaqui*, because the latter have a thumb-like process on the left mandible, and *D. marianae* has a prominent ridge. The pupal mandibles differ from those of *D. modesta*, but were similar to those of *D. rossi*. In *D. rossi*, the first tooth is as far from the next tooth as that tooth is from the apex (Morse and Barr 1990). The teeth of *D. marianae* are not so separate, and the first tooth is closer to the second tooth than that tooth is to the apex.

Distribution: The species has been collected only from the type locality in Dade County, Georgia.

Phylogeny: The species is the sister species of *D. metaqui*, as suggested by the homologues in the larval mandibles, head capsule, and notched frontoclypeal apotome. According to Wiggins (1996), the mandibular process of *D. metaqui* was so different from other *Diplectrona* that it was originally placed in an unknown genus (genus a Ross 1944). *Diplectrona marianae* shares the prominent mandibular process, indicating sister species status with *D. metaqui*.

Etymology: The species is named in honor of Mary Hyatt who assisted in our cave projects.

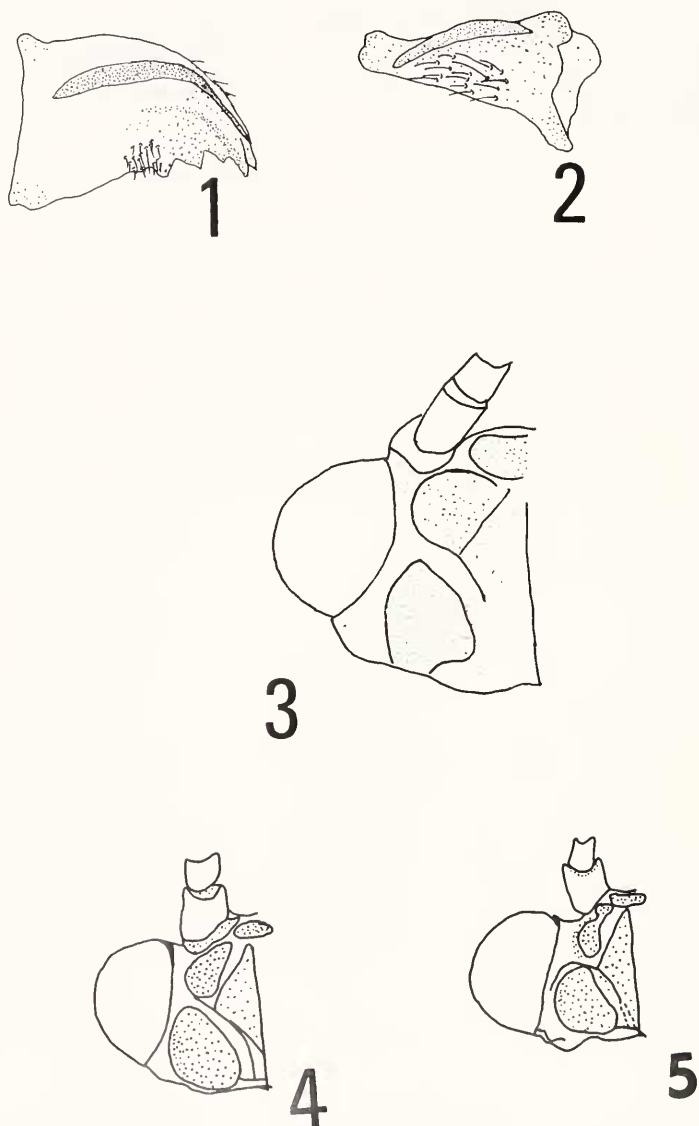


Fig. 1. Dorsal view of the left mandible of *Diplectrona marianae* larva. Fig. 2. Lateral view from the outside edge of left mandible of *Diplectrona marianae*. Fig. 3-5. Left dorsal view of the male heads of. Fig. 3. *Diplectrona marianae*. Fig. 4. *Diplectrona rossi* (Modified from Morse and Barr 1990). Fig. 5. *Diplectrona modesta* (Modified from Morse and Barr 1990).

Biological and behavioral notes

Diplectrona marianae

Five *D. marianae* larvae were collected on 13 March from rocks in the subterranean stream and preserved in 85% ethanol. The larvae were pale in color compared with species of epigeal *Diplectrona*. Four additional larvae were collected on 20 March and five on 27 March. These were returned to the lab in an unsuccessful attempt to rear adults. An adult male was collected in the cave on 22 May. No *D. marianae* were collected from the surface stream; however, other genera of Trichoptera were present.

In the laboratory, larval behavior was recorded from three specimens. The larvae wandered in the laboratory stream and did not build filter nets on the provided screens. However, larvae produced silk strands as anchors while foraging or anchoring debris to the screens. Two of the larvae displayed thigmotactic behavior by crawling between the screen frame and the tank wall. Based on the observation of three individuals in the laboratory, larvae are predators of *P. saltus* and *S. parnassum* and cannibalize smaller instars. *Diplectrona marianae* might be predators of *P. saltus*, *S. parnassum*, and aquatic isopods in the cave environment.

Prosimulium saltus and *Simulium parnassum*

Approximately 30 larvae of *P. saltus* and 180 larvae of *S. parnassum* were collected from the intermittent surface stream. Simuliid larvae do not exhibit net upstream movement (Crosskey 1990), so any immature stages in the cave must reflect oviposition there.

The range of *S. parnassum* is restricted to the mountains of eastern North America. The species is typically found in streams less than 3 m in width, with rocky substrate and steep grade. *Simulium parnassum* larvae are common in surface streams with cave-like features. Typical habitat often includes small streams with dense riparian vegetation that blocks direct sunlight, creating an environment similar to the twilight zone of caves. Females take blood meals from humans and other mammals. The species overwinters in the egg stage, hatching in the spring as water temperatures reach 9.5–10.0° C (Adler and Kim 1986). Our collections of *S. parnassum* from the subterranean stream include 20 larvae on 3 April, one pupa on 9 May, and one larva, two pupae, and three pupal exuviae on 19 May. In 1998 one generation of *S. parnassum* occurred in the surface stream of Newsome Gap.

Prosimulium saltus, an uncommon species inhabiting intermittent streams, has been reported from two streams in West Virginia and the type locality in New York (Stone 1964, Adler and Kim 1986). Our collections of *P. saltus* from the subterranean stream included three larvae on 13 March, three larvae on 20 March, one larva on 27 March, and one larva and one pupa on 3 April. Our collections represent new state records for Georgia and the southern range of the species.

Simuliid specimens of both species from the cave had less pigmentation than specimens from the surface. Larval black fly pigmentation changes have been demonstrated in response to UV radiation, diet, and background color (Zettler et al. 1998). Reduced pigmentation in cave-collected specimens suggests pigmentation as a function of these factors.

Cave environments are less likely to freeze during the winter. The cave stream is closer to the water table and will not dry out during a summer drought. Adults can take refuge from summer heat in the cooler cave environment where females can deposit eggs. Larvae of both species were most mature inside the cave near the mouth of the surface spring. There was a trend downstream of the cave opening, with the earliest instars farthest from the cave. The cave stream was warmer underground during the winter months, and would accelerate development of individuals in the cave. Algal productivity and food availability were highest near the spring on the surface, which would create an optimum habitat combining buffered water temperature and food availability during the winter. Other possible explanations for larval development include competitive exclusion of early instars by more mature larvae that hatched first.

ACKNOWLEDGMENTS

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NOTICE TO AUTHORS

During this coming winter season, I plan to take an extended vacation. During this period, all mail, including papers submitted for publication, reviews, and author revisions, will be held until I return by or before the end of March, 2000. As soon as I do return, I will process all accumulated papers, in the order in which they were received, as quickly as possible.

I trust all authors will be understanding and patient during this diapause. After spring emergence, all will be caught up in short order. Thank you.

H.P.B.